Manufacture and Use of Peanut Protein[1/]

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A satisfactory method for isolating the protein from peanut meal is described and known and potential uses for the protein are discussed, with cost estimates based on the materials involved. The development of a simple and inexpensive means of depigmenting the skins of peanuts prior to processing the kernels for separation into oil and meal provides a raw material which yields a light-colored protein that is suitable for industrial utilization

THE work of this laboratory on the production and utilization of peanut protein has progressed to the point where there should be made available a summary of the methods and operations involved in isolating the protein from solvent-extracted or hydraulic-pressed peanut meal, with a discussion of actual and potential uses for the protein and its by-products.

The cost of processing peanut meal to obtain protein has not been exactly determined, but the process, and its cost, are essentially the same as for the manufacture of soybean protein. By taking into account the yield of protein from a unit of meal and the value of the by-products of known utility it is possible to present an estimated net cost of the protein based on the materials involved.

The manufacture of peanut protein is complicated by a serious color problem owing to the dark red skins (testa) of the peanut. A considerable amount of this color is extracted and precipitated along with the protein under optimum conditions for isolating the protein from the meal. Blanching methods used by the food industries for removing the skins prior to processing are too costly to be practicable for the manufacture of protein for most purposes and the high temperatures employed in the blanching process are deleterious to the protein.

The poor color quality of the extracted protein can be circumvented by the use of white-skin peanuts, and from the long-range point of view, this is probably the most practical way to obtain a light-colored protein from peanuts. However, white-skin peanuts are at present grown only on a limited scale and are not now available in appreciable volume, and probably will not be for several years to come, and then only if a demand is created for them (*3*).

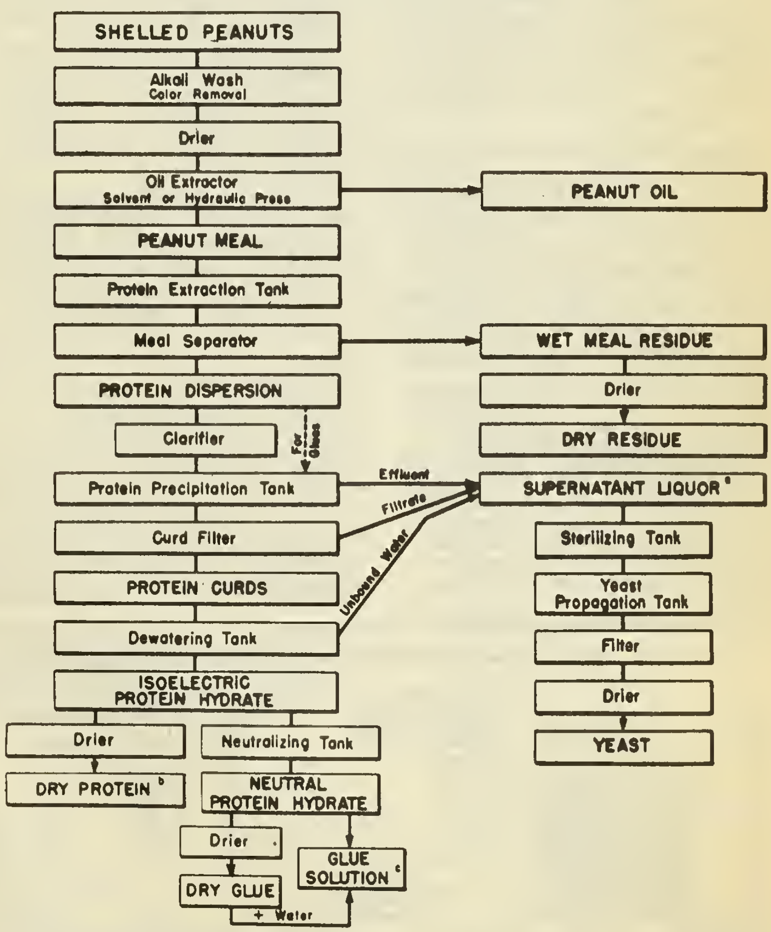
A simple and inexpensive means has recently been found for removing the alkali-soluble color from the skins prior to processing the peanuts for separation into oil and meal. This is accomplished by washing the shelled peanuts in cold 0.5% lye solution, rinsing the kernels to remove excess lye, and drying to the optimum moisture content for preparation of the meal. The protein prepared from this meal is practically free of the alkali-soluble pigments originally present in the skins. The development of this decolorizing process removes the greatest obstacle to the production of peanut protein for industrial purposes.

Preparation and Uses of Peanut Protein and By-Products

An outline of the various steps required in processing peanuts for protein and by-products thereof is shown in Figure 1, which begins with shelled peanuts (kernels) as the raw material of these processes. When white-skin peanuts are used, the step involving removal of the color is omitted; otherwise this operation must be carried out prior to separation of the kernels into meal and oil.

Fontaine and Irving have found that flakes prepared from peanut kernels containing about 8 to 12% water are larger and less fragile, and produce less fines during flaking and solvent extraction in a batch extractor than flakes prepared from peanut kernels containing the normal lesser amounts of water (*9*). The behavior of these moistened flakes in continuous solvent-extraction equipment has not been determined. Flakes of 8 to 12% moisture content are readily penetrated by petroleum solvents (Skellysolves) and permit rapid and complete removal of oil.

Figure 1. The manufacture of peanut protein



a. Contains nonprotein nitrogen, carbohydrates, minerals, and other nonprotein materials.
b. Dry protein from solvent-extracted meal used for fiber spinning. Protein for use as paper coatings, cold-water paints, etc., must be modified.
c. Used as tacky and/or remoistening adhesives (5).

1/ Published in Chemical and Engineering News, Vol. 24, No. 4. Feb. 25, 1946.

While solvent-extracted peanut meal is preferred as a source of protein, there is at present no domestic production of such meal. There is, however, considerable interest in the application of solvent extraction to a wide variety of oilseeds, including peanuts, cottonseed, tung, etc., and a number of industrial concerns, as well as public institutions, are engaged in pilot-plant work in this field. There is every reason to believe that solvent-extracted peanut meal will be available as soon as the necessary processing equipment can be obtained. However, peanut meal prepared by hydraulic pressing can be used to prepare protein for tacky and remoistening types of glues, provided the cooking temperatures do not exceed 220° F. (*5, 10*). A meal prepared under these conditions is also preferred for use as plywood glue (*4*). Meals prepared by the expeller process, which have been examined, are too severely damaged by heat for any use developed to date.

Solvent-extracted peanut meal is used directly for the preparation of protein, but hydraulic press cake must be ground and the fines removed by sifting. The presence of an excessive amount of fines makes clarification of the protein extract difficult. That portion of the meal which passes a 20-mesh sieve, but is retained by a 40-mesh sieve, is preferred for the manufacture of protein.

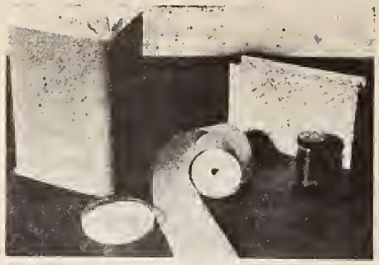


Figure 2. Peanut protein glues can be used for binding books, fabricating set-up paper boxes, and for gummed tape. Dish of dried protein and bottle of glue made from it are also shown

To extract the protein, 10 parts of water are ordinarily added to each part of meal and the pH is adjusted with sodium hydroxide solution to a value of 7.5 to 8.5 (*7*). The temperature is maintained at 25° to 30° C. In commercial practice the most economical ratio of meal to water to employ and the feasibility of making more than one extraction will, of course, depend on processing costs together with the relationship between the value of the meal and that of the protein.

After stirring for about 30 minutes the suspension of meal is passed through shaker screens to remove the bulk of the meal residue and the liquor therefrom is pumped to a settling tank. After settling for about 30 minutes, the liquor is transferred to another tank, a filter aid (Filtercel) is added, and the protein solution filtered through an Oliver precoat filter. Centrifugal clarification can also be employed. The clarification of the liquor from the shaker screen can be omitted when the protein is to be used for the preparation of tacky and remoistening adhesives.

The residual insoluble meal from the shaker screens contains about 87% water and can be dried for feed. The dried residue from a 1 to 10 ratio of meal to water contains about 40% protein. Unpublished data show that this residual meal, on an equivalent protein basis, is approximately equal to the original peanut meal as a poultry supplement.

Soybean meal residue obtained from the manufacture of soybean protein is used in the phenol-formaldehyde type of plastics (*13*) and it is probable that peanut meal residue can be used for this and related purposes.

The protein solution is treated with sulfur dioxide gas to adjust the pH to 4.5 to 5.0. The sulfurous acid formed is preferred for precipitating the protein from solution because of its concomitant preservative action. The protein curd thus obtained by lowering the pH of the solution is allowed to settle and the supernatant liquor removed. The curd is dewatered by heating to about 50° C. (*1*), and then dried at 50° C. Protein prepared by this procedure from solvent-extracted meal is suitable for spinning fibers. For utilization as tacky and remoistening adhesives the dewatered curd is neutralized to pH 6.0 to 8.0 and a preservative is added (*5*). This glue mixture may be used directly or dried at 50° C., and subsequently redissolved as required. Some of the uses for this type of glue are indicated in Figure 2.

The process outlined in Figure 1 must be modified for the preparation of protein intended for use in paper coatings, cold-water paints, and related uses where high adhesive strength is obtained when the natural globular protein molecules are more or less unfolded. Viscosity measurements of peanut protein solutions furnish a useful means of evaluating the over-all influence of the relative degree of unfolding, hydrolysis, and other effects associated with modified proteins intended for industrial use (*6*).

It has recently been found that peanut protein precipitated from solution by hydrochloric acid and neutralized to approximately pH 7.0 with sodium hydroxide solution before drying provides a protein which is suitable for use in confections (*2*).

The supernatant liquor which is removed from the protein curds contains minor soluble protein components, nonprotein nitrogen, carbohydrates, minerals, and other nonprotein materials which were present in the original peanut meal. If the sulfur dioxide is removed from the supernatant liquor or if sulfuric or hydrochloric acid is used to precipitate the protein, this liquor serves as an excellent medium for yeast propagation. In a preliminary investigation about 2 lb. of dry yeast per 100 lb. of peanut meal extracted were obtained when *Torulopsis utilis* was used as a propagating organism, provided the liquor was supplemented with ammonium salts. The recovered yeast was comparable in vitamin content to other feed yeasts on the market (*12*).

Removal of Color from Skins of Peanuts

The removal of the color from the skins of peanuts by means of dilute alkali prior to processing into oil and meal has been carried out on a pilot-plant scale.

A basket and cover made of 4 × 4-mesh galvanized hardware wire cloth supported by an iron framework is loaded to within 3 or 4 inches of the top with ap-

Table I. Results of Color Removal from 100 Grams of Peanut Kernels by Dilute NaOH Solution

Protein No.	Peanuts Used	Conditions: Volume of NaOH solution	Conditions: Concn. of NaOH solution	Conditions: Time	Effect on Peanuts: Water absorbed	Effect on Peanuts: pH	Effect on Peanuts: Oil removed	Effect on Peanuts: Protein removed	Effect on Color[a] of Protein Solution Extracted at Various pH Values: pH of extract[b]	Dominant λ	Purity[c]	Luminous transmittance
		Ml.	%	*Min.*	*Grams*		%	%		*Mu*	%	%
1	Red skin unblanched	150	0.5	1	39	6.9	0.21	0.23	7.5	571	7.8	94.9
2	Red skin unblanched	100	0.5	1	35	6.8	0.27	0.32	7.5	571	8.5	94.4
3	Red skin unblanched	100	0.5	5	42	6.8	0.36	0.21	7.5	572	8.2	93.9
4	Red skin unblanched	100	5.0	1	37	7.1	0.34	0.19	7.5	571	7.8	95.2
5	Red skin unblanched	No treatment			..	...	...	...	7.5	581	27.0	65.3
6	Red skin unblanched	100	0.5	1	..	...	...	...	10.3	572	11.2	90.8
7	Red skin unblanched	No treatment			..	...	...	...	10.0	584	43.0	43.1
8[d]	Red skin blanched	No treatment			..	...	...	...	7.5	572	5.3	94.1
9	White skin unblanched	No treatment			..	...	...	...	7.5	570	5.4	95.6
10	Red skin unblanched	No treatment			..	...	...	...	7.0[e]	576	13.1	85.7

[a] Solutions prepared by dissolving 100 mg. of protein in 25 ml. of 0.02 *N* sodium hydroxide (pH 12.2). Color expressed by means of ICI tristimulus system. Average values for 6 commercial soybean proteins are: Dominant λ 572–75, purity 4.0–8.3%, luminous transmittance 90.3–96.2%.
[b] All proteins precipitated at pH 4.5–5.0 except protein 10.
[c] The lower the colorimetric purity of protein solution, the less color it has.
[d] Proteins 8, 9, and 10 correspond to proteins 11, 12, and 18b reported elsewhere (*8*).
[e] Protein precipitated at pH 6.0.

proximately 100 lb. of peanut kernels and hoisted by a portable crane into a tank containing a 0.5% lye solution maintained at room temperature. The basket is rotated or moved up and down in the solution for about 1 minute, under which conditions the head space above the kernels permits the kernels to circulate freely in the solution as the basket is agitated. The basket is removed and the kernels are rinsed with a spray of water until free of alkali. The kernels are drained and dried at about 50° C. until they reach a moisture content of approximately 10%. The purpose for which the protein is to be used will determine the maximum permissible drying temperatures for the wet peanut kernels. The washing and rinsing process involved is obviously amenable to various batch or continuous operations.

The effectiveness of the use of dilute alkali for removing the color from the skins of peanut kernels is indicated in Table I. Complete details of the method used to evaluate the color of the proteins are reported elsewhere (*8*).

The variations in the amount and concentration of the sodium hydroxide solutions used in the tests and in the length of time the kernels were exposed to alkali did not cause any appreciable difference in the results given in Table I. A fivefold increase in the time of exposure resulted in the absorption of more water; and the use of a 5% sodium hydroxide solution resulted in a very slightly higher pH value for the rinsed and dried kernels. The neutral pH values obtained in all cases indicate that the surface of the kernels may act as a semipermeable membrane, permitting the kernels to absorb about 35 to 40 parts of water but preventing passage of the sodium ions into the cellular interior. Analysis of the lye solution and rinse water showed no appreciable removal of oil or protein from the peanut kernels by the treatments used.

The first four proteins shown in Table I were isolated from peanut meal made from alkali-treated kernels by extraction at pH 7.5. The color of solutions of these four proteins is about the same and comparison with protein 5 isolated from untreated kernels by the same extraction procedure indicates the degree to which the color has been improved by the alkali treatment.

Protein 6 was extracted from the peanut meal at pH 10.3 and the color of its solution is not as light as that of protein 2, extracted at pH 7.5 from kernels receiving the same alkali treatment as No. 6. The color of protein 7 extracted at pH 10.0 from untreated peanut kernels shows the influence of the higher pH value of extraction when compared with protein 5, and the influence of the alkali treatment when compared with protein 6.

The color of solutions of protein isolated from blanched red and unblanched white-skin peanuts (proteins 8 and 9) under the same extraction conditions as were employed for proteins 1 to 4 indicate that the use of skin-free or of white-skin peanuts gives the lightest colored protein but that the difference in color as compared to the alkali-washed kernels is negligible for most purposes.

Protein 10, obtained by extraction at pH 7.0 and precipitation at pH 6.0, contains appreciably less color than proteins isolated outside of this narrow pH range. The additional precautions which are required for its preparation and the decreased yield obtained lead to increased cost of the product and it is darker than protein from alkali-treated kernels.

The cost of the removal of color from the peanut kernels prior to processing for oil and meal must be borne by the protein isolated from the meal. Total costs for decolorizing and drying the peanuts, including amortization of equipment, labor, and alkali are estimated at $1.50 to $2.00 per ton of peanuts. About 300 to 350 lb. of protein can be isolated from a ton of peanuts. Therefore, about 0.5 to 0.75 cent per pound must be added to the cost of protein prepared from peanuts that have been decolorized with dilute alkali.

Cost Estimates

Peanut meal is a by-product of the vegetable oil industry and the cost of the derived protein is based on the value of the meal rather than on the peanuts. The bulk of oilseed meals prepared from cottonseed, linseed, soybeans, and peanuts is used for feeding livestock and their relative values are determined on the basis of their protein content, using the factor 6.25 to convert the percentage of nitrogen to percentage of protein.

Solvent-extracted peanut meal varies from 8.0 to 10.0% in nitrogen content which, in terms of protein, is 50 to 62.5%. In reality, the conversion factor for the percentage of nitrogen to percentage of peanut proteins is closer to 5.5 (*11*) than to 6.25.

Yield values and nitrogen distribution for the products obtained in the manufacture of peanut protein on a semipilot-plant scale are shown in Table II. The loss of material in processing is probably greater than would be encountered in larger scale operation.

The solvent-extracted meal used contained 61.3% protein (N × 6.25). The meal and products obtained are adjusted to a 7% moisture basis. A 1 to 10 ratio of meal to water was used.

Table II. Yield Values and Nitrogen Distribution in Manufacture of Protein from Peanut Meal Containing 9.8% N[a]

(1% moisture basis)

	Yield Calcd. to 7% Moisture *Lb. or %*	Nitrogen *%*	Nitrogen *Lb.*
Meal	(100.0)	9.80	9.80
Meal residue	42.2	7.70	3.25
Protein	33.0	15.56	5 14
Solids in supernatant liquor from protein precipitation	15.7	5.00	0.79
Lost (calcd.)	9.1		0.62

[a] Extracted at pH 8.0 with 10 parts of dilute sodium hydroxide to 1 part meal. Protein precipitated with sulfur dioxide at pH 4.8.

The dry meal residue has approximately the same feeding value as the original meal when placed on an equivalent protein basis; 42.2 lb. of meal residue containing 7.7% nitrogen are equal to 33 lb. of the original meal. Therefore, the net amount of meal required to produce 33 lb. of protein is 67 lb. or about 2 lb. of meal used per pound of protein obtained.

On this basis the net cost of the meal required to produce one pound of protein from meal worth $30 per ton is about 3 cents, for $40 meal, 4 cents, etc. To this must be added the cost of drying the meal residue which contains about 87% water, isolating and drying the protein, and depigmenting the original kernels.

The only complete test made to date on the propagation of yeast was run on the supernatant liquor obtained from the preparation of protein from a hydraulic press meal which had been reduced to a protein content of 46% by the addition of peanut hulls. In this test about 2 lb. of dried yeast were obtained per 100 lb. of meal extracted. A solvent-extracted meal would be expected to yield at least 2.5 lb. of dried yeast.

Even 2 lb. of yeast per 100 lb. of meal extracted represent a gross return of $10 per ton of meal, since the yeast is worth about 25 cents per pound.

Although the data given above are very general, they indicate the cost of peanut protein in terms of the meal used and the by-products recovered.

Acknowledgment

The author wishes to express his appreciation to T. D. Fontaine for the color measurements reported, and to E. D. Parker for preparing the flow diagram.

Literature Cited

(1) Burnett, R. S., *Ind. Eng. Chem.*, 37, 861–4 (1945).
(2) Burnett, R. S., Fahs, F. J., and Hall, H. H., unpublished data.
(3) Burnett, R. S., and Fontaine, T. D., *Ind. Eng. Chem.*, 36, 284–8 (1944).
(4) Burnett, R. S., and Parker, E. D., unpublished data.
(5) Burnett, R. S., Parker, E. D., and Roberts, E. J., *Ind. Eng. Chem.*, 37, 980 (1945).
(6) Burnett, R. S., Roberts, E. J., and Parker, E. D., *Ind. Eng. Chem.*, 37, 276–81 (1945).
(7) Fontaine, T. D., and Burnett, R. S., *Ibid.*, 36, 164–7 (1944).
(8) Fontaine, T. D., Detwiler, S. B., Jr., and Irving, G. W., Jr., *Ibid.*, 37, 1232–6 (1945).
(9) Fontaine, T. D., and Irving, G. W., Jr., unpublished data.
(10) Fontaine, T. D., Samuels, Carolyn, and Irving, G. W., Jr., *Ind. Eng. Chem.*, 36, 625–7 (1944).
(11) Jones, D. B., and Horn, M. J., *J. Agr. Research*, 40, 673–82 (1930).
(12) Klatt, T. J., Parker, E. D., Pomes, A. F., and Porges, N., *Oil and Soap* (in press).
(13) McKinney, L. L., Deanin, Rudolph, Babcock, Glen, and Smith, A. K., *Ind. Eng. Chem.*, 35, 905–8 (1943).